Rules made under Section 234 (d)
of the Land Revenue Act

AND

INSTRUCTIONS

FOR

SURVEY OF VILLAGES

WITH OR WITHOUT
THEODOLITE TRAVERSE PLOTS

AND

DESCRIPTION OF INSTRUMENTS REQUIRED

Published by the authority of the
Government of Uttar Pradesh

ALLAHABAD:
SUPERINTENDENT, PRINTING AND STATIONERY, U. P. (INDIA)
1957

PREFACE

THESE rules and instructions are complementary to the "Rules for the Revision of Maps and Records". The technical portions are taken from the "Instructions for Survey of Villages", written by Mr. G. B. Scott, Superintendent, Land Records Surveys in these Provinces, and published in 1895.

PART I

Rules and Instructions for District Officer or Record Officer; for the Survey Expert and Inspectors

1. *List of villages and patwari circles.*—The Survey Expert or qanungo in charge will prepare from the List I prescribed in the first chapter of the Rules for the Revision of Maps and Records, (*a*) a list of villages, (*b*) a list of patwari circles, in which survey is required. He will further prepare a list of the patwaris and qanungos concerned; and a second list of candidates for survey-training, including patwaris' heirs, candidates for qanungoships, and qanungos, or others who are to be deputed from other districts or tahsils.

2. *Index to circles.*—He will next prepare in duplicate on the pargana maps an index of the patwari circles and villages in which survey is required. Such circles and villages should be outlined in distinctive colours.

3. *Programme.*—Having ascertained the extent of the work before him, the Survey Expert or qanungo in charge will prepare a programme for the approval of the District or Record Officer. He will aim at completing the field work by the 15th of March. He will estimate the number of (*a*) inspectors, (*b*) surveyors required. A surveyor is required on the average to survey 500 acres a month, including the survey of the boundaries, and the division of the villages into quadrilaterals. One inspector is required to supervise about 12 surveyors. A margin of 10 per cent. may be allowed to cover accidents due to sickness, or to the necessity of condemning and re-doing bad work. The Survey Expert will first select as many patwaris as are competent or can be trained to be competent to do the internal survey, if they are provided with an accurate plane table (rule 22) or theodolite traverse (rule 24); and when he has exhausted the number of competent patwaris, he will estimate the number of amins required, and after obtaining the approval of the District or Record Officer, proceed to engage them. Similarly, he will select as many qanungos as he can, who are capable of supervising the work of the surveyors; if more inspectors are required, he will obtain the approval of the District or Record Officer, and proceed to engage them.

4. *Traverse survey.*—The first step is to obtain an accurate traverse of each village, where survey is required. This work is not within the competence of ordinary amins, or of any but extraordinary patwaris. But it is within the competence of qanungos, who possess

a good knowledge of survey, and of the better amins, and of all who are fit for the post of inspectors. If a theodolite traverse exists already, it will only be necessary to test it (rule 24), and to correct any errors which may be found. If there is no theodolite traverse, it will be necessary to make a plane table traverse for each village, in which survey is required. The method of doing this is described in rule 22. As the internal survey cannot be commenced until the traverse of at least one village for each surveyor is completed, and as the accuracy of the internal survey is dependent on the accuracy of the traverse, the selection of men who are competent to test or to prepare the traverse (as the case may be) is of the first importance. Unless he is satisfied that he has already a sufficient number of men, who are competent to do this work, the Survey Expert must form one or more classes—not more than 10 men in a class—of his most promising inspectors and surveyors, and take them out to a village and in their presence himself test the traverse or prepare a new one, sub-divide and plot the village into quadrilaterals, and survey the boundary. He will then, in the same or another village, make each member of the class, do this work, and will not send any man out to test or prepare a traverse, until he is satisfied that he is competent to do it. When there is a large area to be surveyed, and a large number of traverse surveyors are required, the Survey Expert may form two or more classes simultaneously, if he can find competent instructors and a sufficient number of pupils who have already sufficient knowledge of survey to learn the traverse work.

Having obtained his traverse surveyors, the Survey Expert will distribute the work among them in such a manner that the traverse of at least one village for each of his ordinary surveyors may be ready with the least possible delay.

5. *Training of ordinary surveyors.*—At the same time as the traverse surveyors are being selected and trained, and while the traverse of the first batch of villages is being tested or prepared, the Survey Expert will organize classes of the patwaris and amins whom he has selected to do the internal survey. If there are not sufficient inspectors free for the work of instructions, the instructors will be chosen from among the most experienced amins.

Not more than 15 men should be included in a class. Plots of 6 or 8 small villages must be chosen in convenient centres, near roads, and the classes with full equipment must be sent to these centres. Patwaris who have been selected should be kept, as far as possible, in their own qanungo's circle. The instructor will then choose a village, and in the presence of his class, first prepare a traverse, unless one exists already, and then sub-divide and plot the village into quadrilaterals, survey the boundary, and complete the detail survey of one or more quadrilaterals, also a portion of any intricate work that may fall within the plot, as a stream, village site, block of fields enclosed in jungle or ravinous ground, which necessitates the use

of sighting rule. He will next choose the more intelligent of the amins and patwaris, and make them survey other quadrilaterals in the same village on duplicate plots, the rest attending one or other of those surveying, and the instructor visiting and testing the work of each in turn. As each member of the class is considered sufficiently advanced to do so, he will be provided with the plot and *khaka* of one of the other villages chosen, or a section of it, and be made to survey it independently. As soon as all are provided with plots, the instructor will visit each village in turn, and give such other instructions as are necessary, especially testing the position of quadrilateral stations, the recorded measurements on *khaka*, and the plotting from *khaka* on plan, and will run check lines across the work done.

6. *Distribution of surveyors.*—As soon as each member of the class is considered competent to work independently, he will, if he is an amin, be sent to whatever village the Survey Expert may select. If he is a patwari, he will be sent to survey a village in his own circle.

A patwari who does a good survey, should receive a liberal reward. If there are no villages in his circle to be surveyed, the patwari may be employed elsewhere, and will receive the same wages as an amin.

7. *Inspector's duties in checking.*—His first duty, when examining work, is to check the plotting of quadrilaterals from the *khaka*. If the plotting is incorrect, he must at once reject the plot and re-do it, testing discrepancies on the ground personally. If the quadrilaterals are incorrect, the rest of the details cannot possibly be correct.

He will next examine the boundaries to see that no pillars are omitted, next run check lines across completed work, correcting discrepancies under 10 links, rejecting and rubbing out bad work.

He must see that the subsidiary (*shikmi*) lines are run in the general direction of the fields, not diagonally across them, and prevent superfluous chaining. He must see if alluvial lands have been distinguished from permanent.

Even if the first villages surveyed by surveyors have to be rejected and re-surveyed, the experience gained will more than counterbalance the loss of time. But an active inspector should discover bad work before any large area has been surveyed ; nothing but gross carelessness on his part should necessitate the rejection of any large area. All qanungos or inspectors should be thoroughly conversant with the method of survey and the "instructions", before being placed in charge, and should see these strictly adhered to.

8. *Absence of surveyors.*—He must at once report the absence of any surveyor from his work, for whatever cause, as well as non-attendance of village officials when it is their duty to attend, and any want of necessary assistance. Before doing so he should proceed to the spot, and ascertain the exact circumstances personally.

9. *Comparison of boundaries and check.*—When the survey of adjoining villages is completed, he will test the common boundaries by tracing one and laying it on the other. He must prevent surveyors in adjoining villages from making any comparison themselves. He must assist lately trained surveyors where the work is intricate, and instruct them in their duties, where deficient. He should test each surveyor's chain when he visits him, and send his own test chain into camp once a week to be tested with standard bars, unless it has been tested in the meantime by a surpervising officer.

10. *Supply of plots in advance.*—He must be careful to see that no surveyor is kept idle for want of plots, and should send to office for fresh plots some day in advance.

11. *Inspector's final check.*—As soon as a surveyor reports the completion of a plot, he will proceed to the village, run final check lines, and make such other examination as he thinks necessary. If he considers the work accurate, he will make an entry to that effect on the back of the sheet, with date. If he has to reject any work, he will note the area and the number of days spent on its survey, and enter the report in his fortnightly return of work.

12. *Fortnightly returns of work* will be submitted by each surveyor to his inspector, so as to reach him at latest on the 9th and 24th of the month. The surveyor will give the information required for filling up the first five columns of the inspector's form A. On the 10th and 25th of each month, the inspector will send into office a consolidated return in form A, along with the original returns received from his surveyors.

On the same dates, the Survey Expert will submit a diary showing the villages which he has visited each day during the previous fortnight, and the checking which he has done.

On the 1st and 16th of each month, the District or Record Officer will submit, through the Settlement Commissioner or Director of Land Records, to the Board of Revenue a return for the district in form B.

13. *Inking-up details.*—Before the plans are sent into office, the inspector will ink-up his check lines in blue as well as all conventional signs of items other than cultivated fields, and check the reference lists as to names of streams, villages, hamlets, fairs, markets, thanas, tahsil, temples, schools, dispensaries, post offices, district bungalows, factories, ferries, fords, railway stations, etc., and must then send on the plans to office at once, not deferring this till he has several in hand.

14. *Survey Expert's final check.*—On receipt of plans in office, the officer in charge will choose certain villages for checking personally, and arrange for all others to be checked independently, either by special surveyors entertained for this duty, or by inspectors, or kanungos. In the latter case, the inspectors must never be made to run final check lines on plans surveyed by men of their own squads.

The final check lines to be run will be marked on the *khakas*, and these sent out to the purtallers who must, on no account, be allowed to see the completed plans. The purtallers will run check lines in accordance with those marked on *khaka*, registering all measurements in field-books. On completion, they will plot the check lines, and send plot and field-book to office to be compared with survey by the officer in charge personally.

The check plots should show complete fields through which the lines run, and all other items up to two chains on either side, and not merely the field boundary cuttings (*katans*). To make these more useful, and as an extra check on record-writing, the purtaller must number the field through which his line passes, and fill up the items required on *khasra* forms.

15. *When work should be rejected.*—Bad work, that is work vitiated by wrong plotting of quadrilaterals, should be rejected and resurveyed entirely on fresh plots, the originals being kept locked up in office. When errors are confined within a quadrilateral, that quadrilateral only need be re-surveyed, but more check lines should be run in other parts of the plan. Independent final check lines should often follow or cross those marked on plans as having been run by the inspector or qanungos during progress of work.

16. *Disputed boundaries.*—When a disputed boundary has been reported to the inspector, he will proceed to the spot and examine both lines of boundary. He will then send a report with a tracing of the two sets of pillars, and all fields and other items up to 2 chains, or so, on either side the disputed tract, to the Survey Expert.

On receipt, the Survey Expert will compare the tracing with old settlement map. If the boundary, according to that, agrees with either of those on tracing, he will accept that as the correct boundary, and adopt it on the plan.

If on comparison of fields and other items the old boundary can be clearly identified from former map, it will be accepted and adopted, whether it agrees with either of those newly laid down, or not. If any objection is made by the claimants on either side, they must be referred to the District or Record Officer. In such cases, the existence of the dispute and names of opposing claimants will be sent to the District or Record Officer with a tracing showing the disputed lines of boundary, the boundary as taken from the old settlement map, and the fields and other items within and contiguous to the disputed tract up to about 2 chains on either side.

When there is any doubt as to the exact position of the old boundary, the case will be reported to the District or Record Officer for disposal with tracings as before.

17. *Surveyors to accompany officials when settling boundaries.*—Survey Experts will appoint experienced surveyors to accompany any officer deputed by the District or Record Officer to dispose of boundary disputes, and correct or re-lay boundaries. The surveyors will give all necessary assistance to the official during inquiry, and will make a survey of the boundary laid down before returning to office, and get that official's signature as to its correctness.

18. *Supervision of District or Record Officer.*—The District or Record Officer must satisfy himself that the work is being organized systematically, and supervised and checked with thoroughness by the Survey Expert and his inspectors. He should himself, whenever possible and through his Sub-divisional Officers or Assistant Record Officer, make test checks of the work on the ground.

The Board attach great importance to the personal sustained supervision of the Sub-divisional Officer or Assistant Record Officer over the work while in progress, and failure in this respect can never be compensated for by any office check, however careful.

FORM A

Inspectors' fortnightly return *Circle no.* *for fortnight ending*

Total demand

1. Number of villages
2. Area in acres
3. Boundaries in chains
4. Total number of surveyors

1. Number of villages inspected by the inspector during fortnight.
2. Number of surveyors at work during fortnight.
3. Standard of work 500 acres per amin per month.
4. Due in fortnight = $\frac{\text{Number of surveyors} \times 500}{2}$

Nature of work	Surveyors' work				Check by inspector			Remarks	
	Done previously.	Done in fortnight	Total	Balance	Done previously	Done in fortnight	Work rejected to be re-done	Remarks about the work rejected giving name of amin and village, etc. and any disciplinary action, if proposed	General remarks about progress of work. Here the inspector should also give the names of villages under his charge which he has not visited during the fortnight, and reasons why
1	2	3	4	5	6	7	8	9	10
1. Boundary in chains.									
2. Area in acres in which quadrilaterals laid.									
3. Kishtwar in acres.									

NOTE—On the back of this form the inspector should note in brief his daily movements during the fortnight in form (1) Date, (2) Village, (3) Amount of work done.

FORM B

Statement of re-survey work in tahsil———*for fortnight ending the*———

Total demand

1. Number of villages———
2. Area in acres———
3. Boundaries in chains———
4. Total number of surveyors employed for the work———

Number of surveyors at work during fortnight———.

Standard of work———500 acres per mensem.

Due in the fortnight $= \frac{\text{Number of amins} \times 500}{2} =$ ——acres.

Nature of work	Surveyors' work					Check by inspectors		Check by Survey Expert		Record	Remarks
	Done previously	Done in the fortnight under report	Total	Balance	Remarks	Done previously	Done in the fortnight	Done previously	Done in the fortnight	Assistant Officer	
1	2	3	4	5	6	7	8	9	10	11	12
1. Field-book of boundary in chains.											
2. Area in acres in which quadrilaterals laid.											
3. Kishtwar in acres.											

NOTE—Karguzari of 500 acres per mensem includes the boundary *khakas* and the quadrilateral laying of the area.

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PART II

Rules and Instructions for Surveyors and Description of Instruments

PART II

Rules and Instructions for Survey of villages and Description of Instruments used

1. Plans of village lands showing accurately the position, shape, and size of all fields, village sites, streams, limits of jungle, and all other items within the boundaries, may be based on accurate plots obtained by theodolite observations and chain measurements, or on fairly accurate plots made with plane table and sighting rule observations and chain measurements.

2. For the continuous survey of large tracts of country theodolite and chain traverses, or triangulation can alone ensure accuracy; but for survey of small blocks and for training purposes the plane table and chain will suffice.

3. As traversing with theodolite (or its more or less inaccurate substitutes the prismatic compass, circular protractor, etc.), does not fall within the scope of these instructions, the description and use of these instruments are omitted.

4. Most cadastral or field-to-field surveys are now based on accurate theodolite traverse plots supplied by the Imperial Survey Department. Theodolite traverse survey stations are placed at intervals on or near the village boundaries, and also at convenient distances within them, and should also be placed along large streams, and round or through any large blocks of jungle lying within them.

5. On the ground theodolite stations are marked by the platforms at trijunctions of village boundaries, by stone pillars, or baked clay cylinders.

The corresponding points or stations on the plots are usually marked by small circles connected by lines, in blue. These form accurately fixed points on which to base the survey of details as explained in paragraph 24.

Equipment

6. *Equipment*—Field surveyors should be supplied with the following instruments and papers. These should all be carefully examined before issue, and a receipt taken from each individual—

1 Plane table with sighting vane or rule.

1 Chain, full length, with 10 pins.

2 Half chains with 10 pins, or 20-link offset rods.

1 Optical square (or cross staff)

1 Pair compasses, brass, dividers.

1 Diagonal scale, metal or cardboard.

1 Offset scale or slip.

1 Flat ebonite or wooden ruler.

1 Magnetic needle, if work is intricate.

1 Plot of village, or sheet for plot.

1 Sheet rough paper for *khaka* or duplicate plot.

Pencil, rubber, pen, etc.

When employed on regular survey work, he should also be provided with the following:

Reference list forms.

Return of work forms.

Country paper for correspondence.

Description of Instruments

7. *Plane table*—The *plane table* (*Fig.* 1) is a rectangular board placed over a tripod, to which it can be fixed by a clamping screw, passing through the tribrach, or head of the tripod, into a brass plate fixed under the centre of the board. Iron should never be used in the construction of a plane table, as it affects the magnetic needle when that is used. Before using the plane table the surveyor should see that the screws of the tripod and the metal plate under the board are firm and that the board when clamped to the tripod does not move or wobble.

Before beginning work the plotted sheet, or sheet of paper for the plan, should be firmly fixed on the board, this may be done with ordinary drawing pins when the work is likely to be completed in a few days. In regular field surveys it is usual to paste thin strips of fine cotton cloth along the edges of the sheet, and fix this on the board by pasting these strips on to it.

In topographical and small scale surveys when the work of weeks or months may fit on one sheet, greater care is taken. The paper being first fixed on fine cotton cloth, and when dry, the cloth pasted on to the board, or the cloth is first pasted on to the board and the paper pasted on that, so that it may not be easily affected by changes of weather.

8. *Sighting rule*—The *sighting vane* or *rule* in ordinary use is a flat ruler of wood or brass with clean edges about 2 to 2½ feet long, and 1 to 2 inches wide, with uprights, at either end, either firm or hinged. These ends are known, respectively, as the eye and object ends. In the upright at eye end is a hole or narrow slit; at the object end, a wider slit with a wire or thread stretched tightly down the middle. The

outer edges of rule should be exactly parallel to a line drawn from the middle of the slit at eye end to the thread at object end.

The surveyor should be careful always to draw his lines along the edge of rule that touches the mark representing his station on the ground, and it is advisable always to use the same edge. By using the right hand edge, he will find it convenient for drawing his lines with the right hand while holding the ruler firmly in place with his left. The use of it is to get the exact bearing or direction of objects from his point of observation, by laying it with one edge touching the pin or mark on the plan representing his place on the ground, with the eye end towards himself, then looking through the openings in the uprights, turning the rule slowly on his board, till a flag or other object he desires to align exactly corresponds with the thread in the upright at object end. All lines thus drawn will be parallel to the lines seen through the uprights.

For topographical surveys, where referring marks are often at a great distance from the observer or at much higher or lower elevations, a sighting rule with "telescopic adjustment" may be used. A small telescope with an upright pin inside, to mark the centre of the field of the glass, is fixed on a vertical stand attached to the middle of the ruler, working on a movable pivot in a vertical direction, and can be directed accurately to objects far above and below the observer.

This object can be fairly accurately obtained with the ordinary sighting rule if a thread is stretched tightly across the middle of the two uprights immediately above the slits, and aligning the object by keeping this upper thread exactly in line with the thread in the object end upright.

9. *Chain*—Distances on the ground may be measured with rope, tapes, poles, etc., but generally a chain is used. Chains may be of various lengths, those used for cadastral or field-to-field surveys usually, are 22 English yards or 66 English feet in length, and are known as Gunter's chains. These are used because 10 square Gunter's chains are equal to one acre. These chains are divided into 100 links, the links being connected by small rings, and at every 10 links are hung metal pendants, for convenience in counting ; at each end is a brass handle. The last link at either end is shorter than the others by the length of the handles, so that the complete chain includes the handles.

The acre being 10 square chains and the chain divided into 100 links makes it easy to multiply and divide lengths measured by these chains in working out areas, the results being in acres and decimal parts of an acre, that is tenths, hundredths, thousandths, etc., of an acre. Links are expressed in figures as decimals of a chain, thus ·2 chains 54 links are written 2·54 chains. The method of using the chain is given in paragraph 18.

10. *Testing chain*—As chains are stretched by use, especially owing to the junctions in rings opening out slightly, their length should

be carefully tested at intervals. When new they should be tested very frequently, especially when being used in a theodolite traverse. Every chain should be tested before issue ; this is usually done with steel *standard bars* 6 feet in length and about an inch square in thickness, at least two bars are required for the operation. A level piece of ground should be chosen at the central office of every survey party ; this should be carefully smoothened and plastered for somewhat over a chain in length and a foot or so in width. A line should be marked straight down the length with a tightly stretched string, and a square-topped peg driven in at one end with a line cut across the top as a mark for the end of chain to be applied to. One bar is then placed along the line with one end exactly corresponding with the mark on the peg. The second bar is then placed in continuation of the first along the line, care being taken that the ends of the two bars are exactly in contact. The first bar is then carefully removed and the line continued. Eleven lengths give 66 feet, the length of chain. Here another peg like the first should be fixed. The chains to be tested should now be stretched from the mark on one peg to that on the other. If the chain is short, it will generally be owing to one or more of the links being bent, and rectified by straightening them. If long, it can generally be sufficiently shortened by pressing the ends of the numerous rings more closely together. Sometimes it may be necessary to remove a ring. In both cases, care should be taken to see that the lengths from the 50 link pendant to the two ends of the chain are equal.

In large survey parties the inspector or other supervising officer in charge of a squad of surveyors should be supplied with a spare chain to be kept exclusively for testing the working chains. This should be sent into head office at intervals to be tested with the standard measure.

11. *Offset rods*—Half chains or *offset rods,* usually 20 links in length, are used for measuring short distances to bends or corners o f fields and other objects from the main chain lines of a survey. These measurements are called offsets. They should never exceed two chains in length on a survey on the scale of 16 inches to one mile, and should always be run at right angles to the main lines from which they are measured, *see* next two paragraphs.

12. *Cross staff*—Formerly offsets were aligned by a *cross staff*, a piece of board a few inches square, fixed on a stand, and having two lines cut in its upper surface across the board at right angles to one another. In use, one of these lines is made to correspond with the chain line by placing it exactly on that line and looking along one silt on the board to a flag at the further end of line, then objects at right angles are seen to correspond with the other line on either side. But this has been superseded by—

13. *Optical square*—The optical square (Fig. 2) which is a hollow wedge of brass fixed on a small handle to which is usually hung a

plummet at its lower end. The wedge is about 2 inches from base to apex and one-and-half inches at base, the two sides of the wedge are inclined to one an other at an angle of 45° at apex. The base or front of the wedge is open; on each side is a rectangular opening about three-fourths of an inch long by half an inch wide. Under each of these openings, inside the wedge, is fixed a small mirror.

In moving along a line holding the instrument with the plummet and handle vertical, the open face towards the eye of observer, and inclined slightly to right or left towards the object to be observed, and a flag on the line ahead visible through the opening on the further side of the wedge, any object at right angles to the observer's position on the line will be seen reflected in the mirror opposite, *immediately* under the flag.

In taking offsets when surveying, a man with offset rod, or an end of the offset chain, stands at the pillar, field corner, or other point whose position is required. The surveyor moves along the line with optical square in hand, facing the flag ahead, till he sees the offset man in the mirror immediately under, that is in exact line with the flag. He notes and plots the distance on main line from his starting point at back flag, to the spot where he is standing, and then measures and plots the offset at right angles to the main line on plan, *see* paragraphs 17 and 35.

14. *Scales*—As maps and plans of any ground must of necessity be smaller than the ground itself, they cannot be accurately made unless all the lines on the plan are in the same proportion throughout to the lines they represent on the ground, and all angles formed by the meeting of two or more lines on the plan equal to the angles the lines they represent make where they meet on the ground. Thus if it is desirable to make a plan one-tenth the size of the ground, every line on the plan must be one-tenth as long as the line it represents on the ground, and the direction of the lines from one another on the plan must be the same as their direction from one another on the ground.

Most plans must be in a very small proportion to the ground they represent to allow of their being shown on paper at all, and some convenient unit must be adopted both on the ground and on the plan to represent one another.

In English measure a mile of 1,760 yards is usually adopted as the ground unit, and an inch on paper or other material as the plan unit. Then 1, 4, 8, 16 or more inches or $\frac{1}{4}$, $\frac{1}{8}$, 1/16, or less portions of an inch are used to represent a mile of ground on the plan, and the number of inches or portions of the inch used to represent a mile is said to be the *scale* of the plan. Thus the scale of a plan is said to be 1, 4, 8 or 16 inches to one mile.

On plans or maps of large tracts of country which may be required where English measure is not in use, it is also customary to give the proportion or scale as a fraction. Thus a scale of 4 inches to the mile is also the scale of $\frac{1}{15840}$, because 15,840 inches × 4=63,360 inches= one English mile, or in other words one inch on the plan represents 15,840 times its length on the ground.

For ready reference it is also usual to draw a line somewhere on the plan, and divide it into inch lengths, and one or more of these inch lengths are sub-divided into 8 or 10 equal parts. When if one inch represents a mile, each $\frac{1}{8}$th part represents a furlong or $\frac{1}{8}$th of a mile, 1/10th represents 1/10th of a mile, as in *Fig.* 3. This is also called a scale.

When making a plan it is necessary to have some convenient measure or ruler to refer to for each measurement, from which to get exact lengths proportionate to those on the ground. This is also divided into inches, and one or more inches into equal parts of an inch. These rulers made of metal, ivory, wood, cardboard or other material are meant when speaking of a *scale* as an instrument.

Again, as a rope or other measure a mile long would be inconvenient, some smaller length must be adopted for measuring distances on the ground; for this purpose chains are generally used. These may be of any useful length as 100 yards, etc. but the one most largely used for field-to-field surveys is that known as Gunter's chain of 66 feet length, *see* paragraph 9, and the scale in use is that of 16 inches to one mile. There are 80 Gunter's chain in an English mile, therefore, when 16 inches on the scale represent one mile, one inch represents 5 chains= $\frac{16}{80}$ and if an inch is divided into 5 equal parts, each part will represent one chain. If each of these parts is again sub-divided into 10 equal parts, each part would represent 10 links as there are 100 links in a chain; and if these could be again sub-divided into 10 equal parts each of these sub-divisions would represent one link. But as this is practically impossible, a *diagonal* scale is used from which distances of a few links can be measured.

Thus, in *Fig.* 4, the entire length is divided into inches. The last 2 inches to the left are sub-divided at the top and bottom of scale into 5 equal parts each, or 10 parts in the 2 inches. The inch or 5 chain lengths to the right are connected from the top to the bottom of scale by vertical lines, but the sub-divisions to the left are connected by sloping or diagonal lines, running from 0 on the lowest line, of the scale to 1 on the top line, from 1 on the lowest line to 2 on the top line, and soon. The lines at the right and left ends of the scale are also divided into 10 equal parts each, and these divisions are connected across by lines parallel to those at the top and bottom of scale.

If the length required is in complete chains only, the distance can be obtained along the lowest line of scale, thus if 10 chains are required, the compasses are stretched across 2 inches, that is from 0 to the 10 on the right. If 12 chains are required, the compasses are stretched from the 10 on the right to the 2 on the left of 0, that is, 2 full inches=10 chains and 2 sub-divisions=2 chains. But when additional links are required, they are obtained from the diagonal lines. To see how this is done, let the following figure (Fig. 5) represent the portion of the diagonal scale from the vertical line 0 0 to the diagonal line 2 3, the distances between 0 2 and 0 3, respectively, being enlarged 10 times.

If now perpendiculars are let fall from the points where the parallel lines *a a*, *b b*, etc., cut the sloping line 0 1, to the topmost line of the scale, these perpendiculars will divide the upper section 0 1 into 10 equal parts, and if as on the diagonal scale the distance 0 1 represents one chain, each of these sub-divisions will represent 10 links. If the compasses are stretched along the parallel line *e e*, the 5th from the lowest line, from the vertical line 0 0 to the sloping line 0 1, the distance will be the same as from 0 to 5 on the upper line, that is, 5 sub-divisions of 10 links each, or 50 links. If the compasses are stretched from the vertical to the diagonal lines along *a a*, the first parallel line from the lowest line, the distance will represent 10 links; on the second line 20 links ; on the third line, 30 links, and so on, till the topmost line extends to 1 chain. Again, if other perpendiculars were dropped midway between these, they would sub-divide the top line into 20 equal parts, each 5 links in length, so if a distance of 55 links is required, the compasses should be stretched from the line 0 0 to the sloping line 0 1, half-way between the parallels *e e* and *f f*. If the compasses are stretched between the same parallels at one-fourth of the distance from *e e*, the distance will be 52½ links, if one-fourth below *f f*, the distance will be 57½ links.

On the larger scale, if the distance required is 2 chains 60 links, the distance between the sloping lines 0 1 and 2 3 will give the 2 chains, and the 60 links can be got by placing one point of the compass on the sloping line 2 3, at *f*, and the other point stretched along *f f*, to the vertical line 0 0.

Returning to the smaller scale, if the distance required is 12 chains 60 links, place one point of the compasses on the 10th line where the 6th parallel crosses it, stretch the other point along this parallel line first to the line 0 0, which gives 10 chains, then on to the first sloping line which gives 60 links, then on to the second sub-division beyond, which gives 2 more chains, or a total of 12·60 chains.

Or, as less liable to cause mistakes, first measure off 12 chains on the lowest line, then keeping one point of the compasses on the 10th line, and the other on the sloping line 2 3, move the compasses upward to the 6th parallel.

If this is continued to half-way between the 6th and 7th parallels we get 12·65 chains. For intermediate links the required distance between the 6th and 7th parallels can be judged by the eye.

On larger scales, as for instance 32 inches to the mile, the scale may be divided from top to bottom into 20 equal parts, when each part would give 5-link distances on the diagonals ; but so many lines would only cause confusion on a small scale.

15. *Relative values of acres to bighas.*—As mentioned in paragraph 9, an acre equals 10 square Gunter's chains, and as explained above on the scale of 16 inches to 1 mile, one inch on the plan represents 5 chains on the ground, and a square inch on the plan represents 5×5 chains$=25$ square chains or 2·5, that is, $2\frac{1}{2}$ acres on the ground. Measurements by Gunter's chains happen also to be well adapted for converting acres into standard bighas. The standard bigha of these provinces is equal to 3,025 square yards, English, or 55×55 yards.

The side of a square bigha, 55 yards, is the standard bigha chain, known as the Shahjehani, it is equal to $2\frac{1}{2}$ Gunter's chains, or half an inch on the scale of 16 inches to 1 mile, that is, 2 bigha chains to the inch and $2 \times 2 = 4$ bighas to the square inch. Thus a square inch represents $2\frac{1}{2}$ acres or 4 bighas, and we have the proportion $2\frac{1}{2}$ to 4, or 5 to 8 between the acre and bigha. Therefore, to convert acres to standard bighas, multiply the acres by 8 and divide by 5. For example,

$$40 \text{ acres} = \frac{1 \times 8}{5} = 64 \text{ bighas.}$$

In *Fig.* 6 a square inch is divided on the lower line into 5 Gunter's chains, and on the upper line into 2 bigha chains, each inch being equal to 110 yards. If the whole was sub-divided into square Gunter's chains, we would have 25 square chains or 2·5 acres ; and as divided into square bigha chains, we have 4 standard bighas.

16. *Area combs.*—A simple method of extracting areas of fields, however, small and irregular, is based on the above. The instrument used is called an acre comb, or, more correctly, an area comb. This is simply a rectangular piece of talc or other transparent material divided into square inches, and such smaller sub-divisions as are convenient for the standard of area used.

Thus in *Fig.* 7 the sides are first divided into inches, and each inch is sub-divided into 5 equal parts, each of which represents a chain on the scale of 16 inches to 1 mile. Each small square, one square chain, and 10 small squares an acre.

For calculating areas in standard bighas, each inch might be sub-divided into 4 equal parts, when each small square would be 1/16th of a square inch, and represent $\frac{1}{4}$th of a bigha. Or, if the inch squares were divided into 4 parts one way and 5 parts the other way, each quadrilateral thus formed would equal four *biswas*, that is 1/5th of a

On the scale of 4 inches to a mile, each sub-division in figure would represent 4 chains, each small square 4×4 chains=16 square chains, or 1·6 acres.

Similar area combs may be made to suit any required scale or standard of measure. The local bigha differs considerably in various districts, and often in no easy proportion either to the acre or the standard bigha.

The method of using the area comb is as follows :

Let *Fig.* 8 represent an area comb placed over a field, and a scale of chains below (*Fig.* 8*a*). Place one point of a pair of compasses on *a* and measure off *a*, *b*, bring the compasses to *c*, *d*, and stretch the upper point to *e* ; bring the compasses down to *g*, *f*, and stretch the upper point to *h* ; to get the two small sections remaining place the compasses on *i*, *j*, and stretch to line to the left of *i*, then place the compasses on *k*, *l*, and stretch across the little piece to the left but stopping short of the line to allow for the deficiency at the side, place the compasses as now stretched on the scale of chains below and we get an area of 5·30 square chains or 0·53 of an acre, as for each chain length, the compasses have covered a square.

Thus the area of each field or other item can be found, and when totalled, the entire area of a block or village, which is usually compared with the area as found by the theodolite traverse, with the addition and subtraction of offsets, and also with the area as obtained by an instrument known as the planimeter, which records areas by the revolutions of a wheel. These being office processes, are not explained here.

17. *Offset scale or slip.*—The *offset scale* or *slip* (*Figs.* 9 and 10) is intended for plotting short distances on either side the main lines of a plan at right angles to those lines.

The simplest, in ordinary use, is a small flat rule a little over 2 inches in length and half an inch wide. The length of the scale is halved by a line cutting across the middle marked O, *see Fig.* 9. One inch on either side of this line is divided into 5 equal parts, each representing one chain on the scale of 16 inches to 1 mile. Each chain length is sub-divided into 5 equal parts by shoter lines, each equal to 20 links. When plotting an offset, it is very common to measure off the chained distance on the main line from the large scale with compasses, then placing the offset scale at right angles to the main line, the line at O corresponding with that line, then again with compasses marking off the length of offset along the edge of offset scale to right or left as required. This necessitates the surveyor having always in hand, besides his pencil and offset scale, his compasses and diagonal scale. These, being generally of metal, discolour the hands and paper, and the points of the compasses pierce the paper at every offset, as the offset scales are graduated, there is no occasion for this. A better

plan is to first sub-divide the main line, AE in figure, into 5 chain lengths from starting point, with compasses, before chaining along it, then suppose the offset is to be plotted at a point 12 chains from A; place the offset scale along line AE with the O line at C, 10 chains from A, with the point of pencil mark off 2 chains on the main line on the edge of offset scale at *a*, towards E, place the offset scale across the main line AE at right angles to it, by making the middle line O lie along the main line; with the end of line O at *a*, then with point of pencil mark off the required offset to right or left as *b* or *c*.

18. *Magnetic needle.*—The *magnetic needle* (*Fig.* 11) in India is usually in a small brass rectangular box, some 6 to 8 inches long and an inch or so wide with a glass covering at the top. The magnetized needle swings on a small pivot when unclamped by means of a mill-headed screw at one end. Its use is to obtain an approximation to the true north when this has not been obtained by stellar or solar observations.

In topographical surveying, especially in hilly country, it is almost impossible to make a correct plane table survey without it. In field-to-field surveys, when the plane table is used almost entirely as a drawing board, and when the work is done on theodolite traverse plots, the true north is always shown on plot, it is not needed, except on traversing with plane table and sighting rule over short lines, as in surveying large village sites, tortuous streams and through jungle, when deviation from the true direction is almost certain owing to the short distances along which the sighting rule is aligned from station-to-station on the plan. It is also of use when a plane table survey has to be made of a village or block without a theodolite plot to base the details on.

At the N end of the rectangular box is a small graduated scale of degrees to right and left of a middle line marked O. The O is also usually given at the S end for more accurate alignment of needle. When using it the surveyor should be careful to see that the needle swings freely on the pivot.

Variation.—In India, the magnetic north is from about 2 to 3 degrees east of the true meridian, but this *variation* is affected by various causes, and that of different needles may vary from one another.

When the magnetic north is likely to be required during the survey of a piece of land, and the true meridian is shown on the plan, to find the variation of the needle, that is, its inclination from true north, first place the plane table in position over some point on the ground which has been used as a traverse station and send flags to the nearest stations on either side, or to any other plotted points that may be visible. Then with sighting rule make the plotted lines on plan agree with those on the ground as explained in paragraph 24. When the table is in position, place the needle alongside a meridional line with the N and towards the north of the plan. The needle will rest opposite

the number of degrees by which it varies from true north. Unless the table is quite or very nearly level, the needle will not swing freely. By gently moving the box till the needle points exactly to O, and outlining the box in pencil on the plan, the plane table can afterwards be placed correctly to north, whenever needed, which is very useful when working along short lines.

If the plan has to be made without a plot, a meridional line may be drawn down the middle of the sheet on which the plan is to be made, the needle box placed alongside, and the board gently moved till the N end of needle points to O, some mark as an arrow should be made to show which side has been adopted as the north. Care should be taken to see that there is no iron near enough to the table to affect the needle.

When putting the needle box aside after work, always screw down the clamp, which removes the needle from its pivot and fixes it against the glass at top ; this prevents the top of pivot being worn away as soon as it otherwise would be.

Surveying with plans table and chain without theodolite traverse plots.

19. *Placing table in position.*—Having examined the screws of the plane table and fixed a sheet of paper on the board, *see* paragraph 7, the surveyor should choose some point on the outer limits of the block to be surveyed, as a starting point. If the block is a village, he should choose one of the platforms marking the trijunctions of adjoining villages, and place flags or other marks at convenient distances, about 10 to 15 chains apart on or near the boundary, especially at salient angles, but avoiding for the present short turns and very acute corners.

Let *Fig.* 12 represent the block or village to be surveyed, and the points A to H stations for marks placed round it. The observer chooses A for his starting point, and marks all his stations with pegs, and, say, circles some 3 feet in diameter cut in the ground round them. Next he places his plane table with the clamp screw under it, immediately over the peg or centre of his mark, and the board as level as possible, and chooses some point on paper to represent the point A on the ground, so placed, that if possible the entire block or village surveyed from this point will fall within the sheet. A straight line may now be drawn across the sheet to represent the approximate north and south. If supplied with a magnetic needle, he will place one edge of the box along this line, and loosening the clamp screw, turn the table till the N point of the needle is exactly opposite the O, *see* paragraph 18, *Clamp the screw*, mark the north side of plan with an N or arrow, and ; remove the needle box. When the observer has no magnetic needle, he must adopt one side of his plan as the north and place it as nearly as he can judge.

Fix a needle or pin in the point representing A, place the sighting rule on the board with one edge against the pin at A, *see* paragraph 8, and the object end; towards the back flag at H. Then looking through the eye end of sighting rule, move it gently along the board, keeping the edge firmly against the pin at A, till the flag at H is seen to correspond exactly with the thread at object end. Place one hand on the rule to keep it firm, and with the other draw a pencil line along the edge of rule from A towards flag at H. For more careful alignment afterwards it is as well at the same time to draw short pencil lines along the edge of the rule, where it crosses the outer edges of the paper, as *aa*. Then turn the rule, keeping the same edge against the pin at A, towards the flag at B, and align that with thread at object end of rule; draw a line from A towards B, continuing it at the edges *bb*. The angle at A on the ground, between B and H has now been plotted on the board. Next measure the distance on the ground between A and B, and from the scale plot it on the pencil line representing that line on the plan, *see* paragraph 14.

20. *Chaining.*—In chaining, great care must be taken to see that the line is run straight from flag to flag. The chain is held at each end by a man; one being known as the forward, the other the back chainman. The forward man at starting holds 10 pins in his hand, and moves in the direction of the forward flag. When he has gone about a chain's length, he turns to the back man, who motions him to right or left till he is in an exact line with the forward flag, that is, when, as he stoops, that flag can be seen over his head. The back man now places the edge of his handle on the centre of mark, the other draws the chain tight and straight and fixes a pin in the ground at the edge of his handle. They then move forward another chain's length, and each directs the other to move right or left till both the back and forward flags are seen to be in line with the two men; this must be done at each chain. If running straight, there should be no occasion for the back chainman to move from his pin. A second pin is placed by the forward chainman, the back chainman picking up the pins as he reaches them. When the forward chainman has disposed of all his pins, he calls out *ek dahai*, *do dahai*, etc., meaning one 10 chains, two 10 chains, etc., from *das* ten, and receives the 10 pins again from the back chainman after carefully counting them.

21. *Chaining over broken ground.*—Sometimes owing to broken or low-lying ground intervening between two flags, these are lost sight of when chaining from one to the other. In such cases, intermediate flags should be placed so that one forward and one back flag will always be visible. The greatest care must be taken in aligning these.

Thus in measuring the line AB, (*Fig.* 13) when the forward chainman reaches the edge of dip at *a*, he is exactly on the line, AB, a flag should be placed at *a*, and others sent on to *bc*. The front chainman at *a* will see that the back chainman is in line with A, and the back

chainman will then carefully align *abc* and B. Thus the flags on *ab* will always be visible to chainman in the first dip, and *bc* in the second dip.

In chaining up and down slopes if the chain is laid on the ground throughout, the length obtained will be greater than the direct distance across. This error can be rectified by observing the angles of depression and elevation at each change of slope, and applying corrections to each section from a table of tangents, or proportional base and hypotenusal measurements. But in surveying with plane table and chain only, the method of measuring by "cutting links" should be adopted.

Thus in measuring across a dip between A and B (*Fig.* 14), the forward chainman draws his chain as far as the commencement of dip and a few links beyond it to *a*, where his end of the chain, when on a level with A, is some 3 or 4 feet from the ground, say at 50 links. Keeping the chain drawn straight, he will place a staff against the 50th link; and, holding it vertically from this to the ground, he marks the spot. But as the tendency is to slope the staff, a better plan is to drop a pebble from the 50th link and mark the spot. The back chainman comes forward, and holding the 50th link puts the end on the spot marked by the pebble. The forward chainman continues down the slope till he is some 3 or 4 feet lower, and again drawing the chain straight and level, drops another pebble, and marks the spot under *b*. The process is repeated till the full chain is measured, and the pin placed.

In moving forward up a slope, the back chainman raises the chain-dropping pebbles, and the forward man marks the distances on the ground ahead. Thus the ground between the flags has been practically divided into terraces with vertical sides, the sum of their lengths giving the direct distance from A to B.

22. *Traverse with plane table.*—Returning now to Plan (*Fig.* 12), the station B having been plotted, the surveyor sends a flag to C, places his table over B, with the screw loosend and exactly over the mark as at A. If he is using a magnetic needle, he places this as at last station, and turning the table till the N end of needle points to O, clamps the screw, and proceeds to align his back and forward flags. If he has no magnetic needle, he fixes a pin in B and another in A on his plan, and places his sighting rule with an edge against the two pins, that is, along the line A B on plan, and the continuation of that line *bb* with the object end of the rule towards back flag A. He now turns the board, the clamp screw being loosened, till flag A exactly coincides with the thread at object end of rule, when the observer looks through the eye end. He clamps his screw, and turns the sighting rule till the flag at C corresponds with the thread at object end, and draws a pencil line along edge from B towards C. The second angle is now plotted. He

next measures and plots the distance to C, and thus continues from station to station all round the block till works back to A. The last distance HA, and the direction of line HA on the ground, should correspond exactly with the distance and direction on the plot. If not, there has been an error made in going round, or more likely an error has gradually accumulated. In this case the surveyor should start again from A and work back to HG, etc., till the error has been discovered or eliminated.

The plot is now ready for the survey of interior details, but before proceeding further, the surveyor should test the plot by aligning flags across the ground from north to south and east to west, and measuring the distances, to see if they agree exactly with the plotted distances of the block. The method is more fully explained in paragraph 30.

23. *Surveying from a central line.*—Another method of surveying without a plot is first to choose a central position in the block to be surveyed, and to place flags at convenient distances, say, from 10 to 15 chains apart, north and south of it up to the limits of the block, and carefully align them. Let *Fig.* 15 represent the block to be surveyed, and *a*, a central point chosen to start work from. Send flags to *bc* to the north and *de* to the south of *a*. If the surveyor has a plane table and sighting rule and a magnetic needle, the simplest plan is to draw a straight line across the board, and choose any central point as *a* on it. Place the magnetic needle box along the line *a*, and unclamping the screw, turn the table till the needle points to O. Clamp the screw after marking the north of board, then placing a pin in *a* lay the sighting rule along the line, and turning it first to the flags to the northward, motion the flagmen to right or left till all are exactly in line with his sighting rule. Then turn the rule to south and align the flags in that direction. If he can see right across the block he should test his line of flags by going to the outermost one at one end and see if all agree to the other end. Returning to *a* he can now send other flags to right and left as *fg* and *hij* as nearly at right angles as he can judge, and do the same at the flags to north and south of *a* at about equal distances apart. The block will now have been divided into quadrilaterals. This can be done by eye alone almost as easily, without plane table, the direction of north being judged as nearly as possible.

The surveyor should now measure all the sides of his quadrilaterals from flag to flag and all the diagonals, registering the distances in figures in a field-book, or on a rough plot or *khaka*. A mark as a peg should be placed at each flag station, and a circle cut in the ground round it.

Then starting from the central point *a* on his plan, he should plot and mark off the distances to *bcd*, etc., along the central line. Then with compasses, plot the corners of his quadrilaterals on either side the central line by diagonal distances, checking each by the side distances. From the corners of these quadrilaterals he can go on extending the plot

to the outer limits of block. This done, he should test the distances of the outer flags from one another, and, if working with a plane table, test their direction from one another also. If he finds all these correct, he may now proceed to survey the details, *see* paragraph 34.

As a rule, there will be a certain accumulation of error from the centre outwards by this method, therefore it should only be adopted when there is no plot, and the outer limits of the block to be surveyed run through heavy jungle or along tortuous streams where short lines will be necessary, and, in consequence, difficulty in traversing round the outer limits correctly. The sides of the quadrilaterals need not be equal, nor the angles exactly right angles, as the distances are plotted from the lengths of diagonals.

Surveying on plotted sheets

24. *Testing plot.*—When provided with a theodolite traverse plot of the village or block to be surveyed, the first duty of the surveyor is to test the accuracy of the plot by comparing the angles and distances of the plotted stations on the plan with those on the ground. The plot of a village may be on one or more sheets ; when on more than one sheet, the surveyor should complete the survey of one sheet at a time, generally beginning at the north-west corner.

Choosing a trijunction platform or other traverse survey mark, as for example A in *Fig.* 16 he should place his plane table over it, as nearly level as possible, with the clamp screw over the centre. Unclamping the screw, and placing his sighting rule on the plotted line AJ he will turn the table till on looking through the eye end of rule, *see* paragraph 8, the flag at J is in a direct line with the thread at object end. He will then clamp his screw, and turning towards the flag B will test its direction also with sighting rule, this should correspond with the plotted line AB. He will then chain the distance to B, and test the line on plan with scale and compasses. He will thus proceed from station to station all round the plot, and afterwards also test all subsidiary traverse lines and stations plotted on the sheet.

He should note at each station what kind of mark has been used for permanently marking it. If a stone, he should make a △ round station, and enter the word *pather* (stone) in pencil alongside ; when it is a clay cylinder, he will write *bamba* (pipe).

If in testing the accuracy of a plot any station on the ground is found to disagree with the station on the plot, either that on the ground has been moved or that on the plan has been wrongly plotted. In such cases, when the surveyor is under the orders of a supervising officer, he should at once report the case to him, and after testing again, the discrepancy should be rectified in the following manner :—Either correcting the station on the plot from that on the ground, or relaying that on the ground from the plot.

In the plot, *Fig.* 16, let station E be the one that disagrees. Placed the plane table in position on station D, and carefully align flag at C, an also, if possible on B, with sighting rule. Turn the sighting rule, and align it with the flag on required station E′, draw a pencil line in that direction, measure the distance to E and plot it. Next place the table on the newly plotted point E′, aling the flag at D, turn sighting rule to F, and if the direction corresponds, measure the distance E′ to F and test it on plot. If it disagrees, the operation must be repeated.

If the plotted station is considered correct then in order to fix the corresponding point on the ground, place the table in position at D align C or B, then place sighting rule along plotted line DE, and sending a flag forward in that direction to a little beyond the required distance as well as can be judged, move it right or left till it exactly corresponds with sighting rule on line DE, measure a distance towards the flag equal to the plotted distance DE, and mark the spot ; place the table over this mark, align it with back flag at D, and then with forward flag at F measure the distance EF. If the direction and distance to F agree with plot, the desired point has been fixed, and can now be used as a survey station.

When testing the accuracy of the plot as above, all measurements should be recorded on a duplicate plot or *khaka* in fugures, *see* example of *khaka*, *Fig.* 21.

Experienced surveyors usually take offsets to the boundary pillars while testing the traverse lines, registering them on the *khaka* ; they also mark the field boundary cuttings (*mendh katans*), and choose stations for the corners of quadrilaterals (*marabas*). With in experienced men, each process should be carried out separately, so that the mind might not be distracted from the special work in hand.

Survey of Boundaries

25. *Boundaries.*—The accuracy of the plot having been tested if the entire plot is on one sheet, the surveyor should now take up the village boundary pillars. This should be done on the *khaka*, and the length of each offset registered in figures to be plotted afterwards. The *khakas* will be preserved until the maps have been finally checked and passed in office.

Starting from the trijunction platform at the north-west corner, or any other convenient station, the surveyor should again chain from station to station, and fix each pillar by rectangular offsets as he goes along, *see* paragraphs 13 and 15.

As a rule, offsets should not exceed 1½ chains in length, but occasionally it may be convenient to take up pillars at from 2 to 3 chains' distance. In such cases, offsets of 2 chains should be checked by a tie line; and those of 3 chains, by two tie lines. If the boundary pillars, or the smaller bends of streams on a boundary, be at a greater distance from

the traverse lines, subsidiary lines should be run and carefully checked by the lines, an offsets taken from them, as in *Fig.* 17.

When boundary pillars are placed in fields the outer limits of the fields in which they lie must be surveyed. This is seldom the case, except when there are disputes, and the plans of the fields will be of use when inquiries are being made on the subject, or when the new survey is compared with former settlement maps.

26. *Streams on boundary.*—When a stream forms the boundary, it must be surveyed from one high bank to the other, on both adjoining villages. If it is too deep to chain across, a set of lines must be run down either bank, and connected across at intervals, by chaining where possible, or by intersections with sighting rule from two or more fixed points, as in *Fig.* 18.

The name of the stream, the direction of the flow, and the heights of its banks, at intervals of about half a mile a part, should be entered on plan in pencil, and a note made as to whether the boundary is mid-stream, or on one bank. On narrow streams, the boundary can be shown by dots on one side; or when the boundary is mid-stream, by dots on both banks alternately.

27. *Large river on district boundaries.*—When a large river forms the boundary between two districts, the channel that the largest boats follow in the dry season is to be entered on plan, as it indicates the deep stream, which is the legal district boundary.

28. *Boundaries to be surveyed in duplicate.*—The boundaries of every village should be surveyed all round independently, so that those of adjoining villages may be mutually checked after survey. Surveyors in adjoining villages must not be permitted to make comparisons or tracings of each other's work.

29. *Disputed boundaries.*—When a boundary is disputed, and there are two sets of pillars on the ground, both lines must be surveyed and shown on the plan.

When the breadth of the dispute is narrow, the traverse lines are generally run between the two sets of pillars. When it is wide, one set of traverse lines should be run near each set of pillars. If this has not been done, the surveyor should run subsidiary lines along the pillars furthest from traverse lines, carefully checking them by tie lines from the traverse plotted stations, as in *Fig.* 20.

In all such cases a report must be made to supervising officer, and a tracing sent with report showing both lines of pillars, and all fields of other items lying between or adjoining them up to $1\frac{1}{2}$ chains on either side of the dispute. The surveyor must not attempt to settle or adjust any disputed boundary, even if asked to do so by one or both parties. A specimen of plot with boundaries is shown in *Fig.* 19.

Sub-division into Quadrilaterals

30. *Quadrilaterals.*—Thes urveyor will next proceed to sub-divide the village into quadrilaterals (*marabas*). When the village is fairly open, and the view unobstructed, this is done by aligning flags in straight lines across the village from traverse stations on the north to those on the south, or from east to west, or to and from convenient points on the lines connecting the traverse stations. These points should be from 10 to 15 chains apart, longer or shorter, according to the size of the fields to be surveyed, and should, as a rule, follow the run of field boundaries, and not be run diagonally across them. They should never be placed inside fields, but on field boundaries (*mendhs*) or uncultivated ground, and on the outer edges of roads and pathways. At each quadrilateral station a peg should be driven into the ground and a *markas* or mark, a circle about 3 feet in diameter, cut in the ground round it, but without injuring standing crops.

31. *Duplicate plot or* khaka.—The plane table can now be put aside for a time, and the duplicate plot or *khaka* used, on this the positions of quadrilateral stations should be entered approximately, and the lines carefully measured from one side of the plot straight on to the other side.

Evey field or other boundary crossed should be marked where the chain crosses it, with a straight narrow cut on the ground, and the measured distances from starting point entered in its place approximately on the *khaka* in figures.

The distances of all quadrilateral stations and the total length of lines should be distinguished by a circle drawn round the figures, or they may be underlined. A specimen of *khaka* is shown in *Fig.* 21.

In laying out quadrilaterals it is not necessary to have all the sides equal, nor the angles right angles; the positions of stations must depend on the lie of fields, and the positions of field cuttings on the traverse lines and the traverse stations.

32. *Crossing obstacles.*—Deep water should, if possible, be avoided on quadrilateral lines; on no accouut should any man be sent into water beyond his depth. Small sized tanks and narrow streams might be measured across by long ropes, which should be either wet or dry throughout, and compared with the chain *after* measurement, not before. But if the breadth is too great the distance across may be obtained by laying off a rectangle by optical square in the manner shown in *Fig.* 22.

Having placed flags on either side the tank at *cd* in line with AB with optical square at *c*, lay off any line *ce* at right angles to AB; measure and plot *ce*, at *e* align a flag *f* at right angles to *ce*, at any convenient distance from *e* at right angles to *ce*; measure along *ef* till reaching the point *g*, from which the flag at *d* is seen by optical square to be at right angles to *ef*; plot the point *g*, measure the distance *gd*.

The line *gd* should be equal to *ec* and *eg* equal to *cd*, plot *d* and con-

tinue the line to B. Small village sites and other small obstacles may thus be avoided, if necessary.

If a deep stream crosses the line AB as in *Fig.*23, place flags at *cd* in line with AB ; at *c* with optical square, align a flag *g* at right angles to A *c* somewhat longer, than twice the distance *cd* as nearly as can be judged. Measure along this line to any point *e*, about as far as *d* from *c*, fix a flag and plot *e*, continue along the line towards *g* to *f*, making *ef* equal to *ce*, at *f* align a flag *h* at right angles to *cf*, measure along *fh* till reaching the point *i* from which the flags at *ed*, are seen to be in one straight line, the ditance *fi* equals the distance *cd*, plot *d* and continue the line to B.

33. *Plotting from* khaka.—When the quadrilaterals have all been measured and the distances, field cuttings, etc., recorded on the *khaka* the surveyor must next plot these on the original plan with scale and compasses. He should first plot all quadrilateral stations that fall on the traverse lines, marking each with a small circle ; then draw pencil lines across from starting to closing points of each measured distance, and carefully test the full distance across.

If the difference is large, it is evident the chaining is wrong and must be re-done, but if not more than can be accounted for by the stretching or contracting of paper, or perhaps too slack or too tight chaining, he will sub-divide the difference as follows :—Supposing the length of line to be 41· 50 chains, he will first measure off 1· 50 chains from one end, and divide the rest of the line with compasses into 4 equal parts, if the difference on the whole line had been 8 links, this will have been applied as 2 links correction to each 10 chains. If the length of the whole line is 58· 10 chains, prolong the line at one end by 1· 90 chains, thus making the whole line 60 chains, and divide the whole line into 6 equal parts. If the total difference had been 12 links, 2 links will have been applied to every 10 chains.

Once the quadrilaterals are correctly measured and plotted, it is evident there can be no accumulation of error afterwards. The surveyor should be careful to place his flags exactly in line, to chain straight from point to point, *see* paragraph 18, to draw his lines on plan perfectly straight, and to carefully distribute the small differences when plotting.

Having plotted the quadrilaterals, the surveyor must next plot all the field boundaries cut by the lines, *mendh katans*, as recorded on his *khaka*. He has now numerous fixed points from which to lay down subsidiary or *shikmi* lines for the survey of details. The *khaka* can now be put aside, and the rest of the work plotted directly on the board plan; no more distances need be recorded in figures. The method of detail survey is given in paragraph 35.

34. *Marginal lines—when plot is on more than one sheet.*—When the plot of a village covers more than one sheet, it is necessary, after

testing the plotted stations, to lay down lines on the ground corresponding with the edge or marginal lin s of adjoining sheets, unless sub-traverse lines and stations lie in close proximity to them, in which case it is best to carry the detail survey as far as those lines on either side.

If sub-traverse lines run at a distance of 10 or 15 chains from the margin, the marginal lines and stations can be laid off from these by laying out quadrilaterals directly from them, the required distance to the margin. But when there are no sub-traverse lines near the margins, it will be necessary to play them off with sighting rule in the following manner:—In *Fig.* 24 let WXYZ represent the marginal lines of a sheet, and *abcde* plotted points on it. It is usual to draw lines from the last plotted stations near the margins of adjoining sheets, as *ae*, to those margins in the direction of the nearest stations in adjoining sheets, as *mf*.

After testing the plotted stations, mark off the point on the line *ef* where it crosses the margin YZ on the plot and on the ground, and register the distance on the *khaka*. Fix the plane table in position at this point, that is aligning the sighting rule along *ef*, next day the sighting rule along the marginal line YZ on plan, and send flags to convenient distances of from 10 to 15 chains apart, and carefully align them. Measure and plot the distances from point to point till the distance *f* Y has been covered according to plan. Place a mark with circle at Y and at each intermediate flag, and record the distances on *khaka*. Then proceed to *a*, place the table in position aligning it on *am*, *ab*, measure along *am* till reaching the marginal line XY, mark the point and record the distance on *khaka*. Place the table in position at this point, and align flag along margin as before to Y, measure, record, and plot the distances. The point Y as ascertained from *am* should exactly correspond in direction and distance with the mark previously fixed from *ef*; if not, the process must be repeated till the lines are correctly laid. This done, the surveyor can now lay out his quadrilaterals, using the stations on margin as terminal traverse lines.

Survey of Minor Details

35. *Survey of minor details.*—Having completed the survey of boundary and plotted his quadrilaterals and *mendh katans* from his *khaka*, and, where necessary, laid out marginal lines, the survey of details can now proceed. This is done by running subsidiary or *shikmi* lines from and to fixed plotted points on the quadrilateral lines, straight across the quadrilaterals, generally parallel to their side, either from north to south or east to west, according to the general lie of fields. The lines should be run on, or as close to field boundaries as possible, so as to make the offsets short, and to cause the least possible damage to crops.

Choosing some point on a field-cutting, *mendh katan*, about 2 chains from one corner of, say, the north-west quadrilateral, the surveyor will fix a flag here, and another about the same distance from the opposite

corner of the same quadrilateral. Beginners, especially, should be careful to test the distances between these flags and the nearest quadrilateral stations, by chaining, before beginning work on them.

He will next chain along the line between the two flags, straight across, from flag to flag; marking on the ground, and at once plotting on his plan all field boundaries, roads, streams or other items, where his chain crosses them, and also taking offsets to all junctions, corners, and bends of fields, and other items on either side the *shikmi* line up to 1 1/2 chains, *see* paragraphs 11, 13 and 15. No record in figures is required of these.

The field-cuttings should be marked, as before said, by straight narrow cuts on the ground, and the positions fixed by offsets by small circles.

The full length of this subsidiary line should agree exactly with the distance on the plan of the points previously plotted on the quadrilateral lines. Having finished work on this subsidiary line, he will remove his flags to other cuttings on the same lines, about 2 chains further, and proceed to fill up the details along this line. Thus by degrees every item in the quadrilateral can be carefully and accurately plotted in its place on the plan. Work in one quadrilateral should be completed before beginning in another. The number and distance apart of the subsidiary lines will depend on the size of fields, no unnecessary lines should be run. The system of running these lines diagonally across the field should be discontinued, as they necessitate long offsets, and often cause needless injury to standing crops. When joining the corners of fields on the plan, the surveyor should be careful to see that these lines correspond with the field boundaries on the ground.

36. *Injury to crops to be avoided.*—Chaining through wheat, rice, flax and other low crops can be done without injuring them, especially if the lines are run as closely as possible to the field boundaries.

But when such crops as sugarcane, *arhar*, poppy, etc., are on the ground, it will often be necessary to measure round each field, in succession and plot each in turn. In such cases care must be taken to connect the work carefully to fixed points on quadrilaterals on all sides, thereby checking the intermediate chaining. If when closing on fixed points the distances disagree the work should be re-done.

37. *All items to be carefully measured and plotted.*—Every boundary on the ground, whether of stream, grove, village site, tank, etc., must be carefully measured and plotted, except temporary field boundaries when these lie inside a single tenant's holding, such as are made for irrigation purposes only. Field limits, which are on the ground at the time of survey, must not be omitted or obliterated, even if so desired by the Zamindars or others.

38. *Conspicuous objects.*—Mile-stones, bench-marks, wells and other conspicuous objects must be carefully plotted from actual measurements. Conspicuous isolated trees must also be shown in their exact positions on plan. Of groves, only the outer limits and interior partitions of ownership, if any, are to be plotted.

Spires of temples, if not already plotted by traverse, should be fixed by intersections with sighting rule from at least three fixed points, and the corners of masonry enclosures or basements fixed by offsets. This should be done whether the temples are in the open or lying in groves or jungle, as they form useful permanent marks for future work.

39. *Village sites.*—Sighting rules should be used for the survey of village sites, all roads and thoroughfares should be carefully plotted; all fields, gardens, tanks, etc., within it should be separately shown.

40. *Enlargements of small divisions.*—If the side has to be further divided into separate proprietor's shares, and the scale will not admit of these divisions being shown, an enlargement for the purpose should be made on one side of the sheet outside the plan.

41. *Enlargements of fields.*—The same should be done when small blocks of fields in a village are too small for the scale.

42. *Roads, etc.*—All roads, cart tracks and footpath from one village to another should be carefully surveyed, whether they run through cultivation or waste, and a note made on plan of the places from which they come and to where they lead.

43. *Railways.*—Railway lines, with banks and fences, are to be carefully plotted and mapped in accordance with the conventional signs used in the Survey of India Departments.

44. *Masonry pillars, mile-posts, etc.*—All masonry pillass, mile-posts, stone marks, etc., near railway lines, canals and roads, and all level-crossings, bridges, etc., are to be shown.

45. *Telegraph lines.*—Telegraph lines are to be shown, except along railways.

46. *Ravines.*—In delineating ravines where they cover extensive areas, the main arteries should be carefully surveyed, as well as the openings of minor branches of about 10 chains in length leading from them, but the remainder should be treated as one block, only the outer limits being taken up by offsets, and the conventional sign for ravines entered, *see Fig.* 26.

Cultivation lying among ravines should be carefully surveyed and shown in its proper place on the plan. The subsidiary lines from which it is surveyed should be connected on both sides to fixed points.

47. *Strips of waste.*—Strips of waste which the scale admits of showing separately must not be included in adjacent fields, unless they are a portion of the cultivator's rent paying lands, in which case their limits will be shown by dots.

48. *Jungle.*—Large blocks of jungle lying within a village may prevent the entire area being divided into quadrilaterals without much cutting and clearing. If there are no items required to be shown, lying within the jungle, it will suffice to run lines near enough round it to fix the limits by offsets, but any cultivation lying within the outer limits, as well as fallow, streams, roads, pathways, tanks, temples and other items, must be carefully surveyed and plotted. Theodolite traverse lines should always be run through jungle blocks when there are inlying items to be surveyed; if this has not been done, the surveyor must run his own lines through it so as to pass through or close to cultivation, etc., required to be surveyed. These lines should invariably start from and close on theodolite or quadrilateral stations, or fixed points on the lines connecting them. When it is necessary to clear such lines through jungle, this should, if possible, be done while the surveyor is engaged on other duties, by the *mirdaha*, or some man sent for the purpose by the supervising officer, to save time. The width of the clearing should just suffice to allow of the flags being mutually visible, and large trees should be avoided. The lines should run through or near the edges of enclosed cultivation or fallow, temples, etc. and follow the windings of streams, or run along pathways and roads. If the lines are fairly long and not too winding, they may be accurately traversed by sighting rule, but when short or tortuous, the magnetic needle should be used to fix the table in position at each station, and the back flags referred to as a test, *see* paragraphs 8 and 18. Starting from the fixed point at one end of the series, he should then place his table in position by reference to the flags on the stations on either side, and his magnetic needle before drawing his forward line ahead.

He should continue the traverse without taking up details, till he has closed it on some fixed point at the other end, and should be careful to see that his last bearing or direction and distance are correct; if not, he should, work back closing to starting point till his error has been found or gradually eliminated, and then return to take up the required details. To do this before completing the series would, in case of a final discrepancy, only cause confusion, unless the various measurements were recorded in figures in a field-book or duplicate plot. By the constant use of the magnetic needle at each station of the series the result is far more likely to be correct at the closing point.

49. *Hills.*—When hills lie within the lands of a village or skirts them, the bases only should be shown on the plan (*Fig.* 27) unless a contour survey is made, as otherwise the conventional signs may be misleading. A slight fringe of hachures may, however, be placed near the base as a distinguishing mark, and the word "hill" written inside. Any well marked peaks, temples or other conspicuous marks on the top or slopes, should be carefully fixed by intersection from not less than three fixed points on the plan, or by careful chaining from stations below when the distance is short.

50. *Conventional signs.*—All items other than lands under crop should be distinguished on the plan by the conventional signs used by the Survey of India Department. The surveyor should enter these in pencil at time of survey, and the supervising officer should ink them in blue colour before sending the plans to office.

51. *Reference list.*—If *khasra* writing does not immediately follow the survey, each surveyor should keep a "reference list". He will give numbers to all items other than cultivated fields on the plan and enter each item with its corresponding number on the reference list. In this he will also enter the official name of the village correctly spelt, as well as any local names in use; also names of streams, hamlets. tanks, temples, thanas, tahsils fairs and markets with the days on which these are held, and any other conspicuous objects shown on plan; also places from and to which roads and pathways lead, and any other information that may be useful in compiling a district map afterwards.

52. *Alluvial lands.*—Alluvial lands in a village must be marked off from permanent lands by a thick line, and when the *khasra* is written up, the fields and items in alluvial lands must be numbered independently of the rest of the village, and a separate *khasra* must be prepared for each tract

53. *Entries on back of sheets.*—On the back of his sheet he should enter the name of the village in ink; also dates of commencing and finishing each sheet, the total number of fields an other items, and the approximate area found by counting the number of square inches. One square inch on the scale of 16 inches to one mile being equal to 5 chains by 5 chains or 2·5 acres.

54. *Diary.*—Every surveyor must keep a diary, and enter daily the number of fields and acres surveyed any days spent in marching, causes of short work at any time, rain, etc. A fortnightly return of work must be filled in from the diary and regularly forwarded to the Qanungo or Inspector.

Computing of Areas

55. As soon as the field-book is completed the areas of every plot of ground given in the maps must be computed in the office; they will be calculated with the area comb (rule 16) independently (*a*) by each patwari for his own villages and (*b*) by a professional estimator. The calculations will be compared and the result passed by a trained estimator.

56. The two independent calculations must agree within one per cent before the result can be accepted. If the difference is larger, the examiner must again have two independent calculations made, and so on, until he is satisfied that the result is accurate within a margin of one per cent.

57. The total of each column of the area form must then be found, and an abstract of the column totals will be made to give the grand total of the village by summation of fields.

58. The area of a village by summation of fields should be compared with that obtained by adding up the areas of the whole squares and parts of the squares lying within the plan and that calculated by planmeter. They should all agree within 1 per cent.

Fig. 1.
Plane Table and Sighting Rule

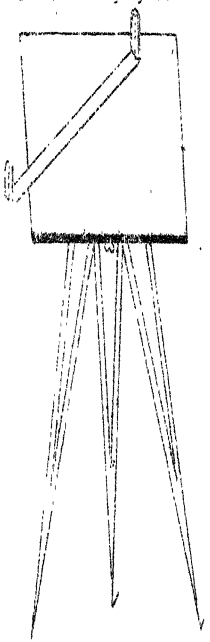


Fig. 2.
Optical Square.

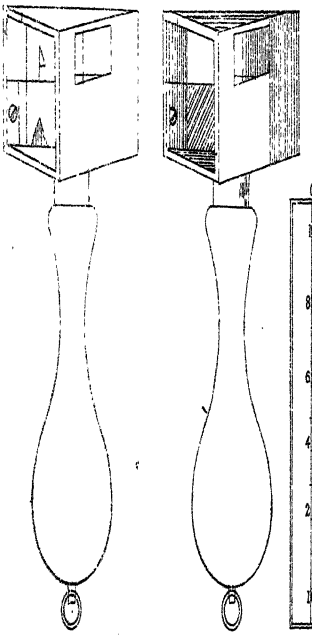


Fig. 3.
Scale of Miles.

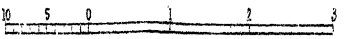


Fig. 4.
Diagonal Scale, 16' = 1 Mile.

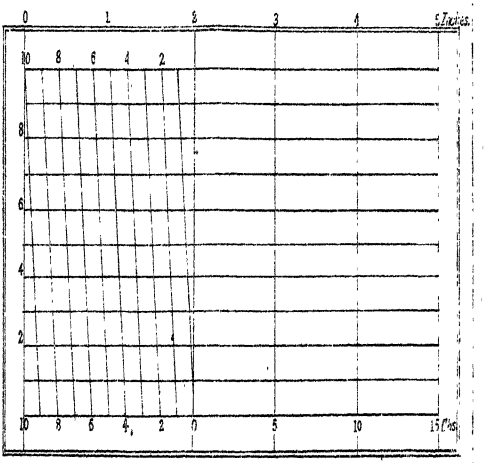


Fig. 5.
Enlargement portion of Diagonal Scale.

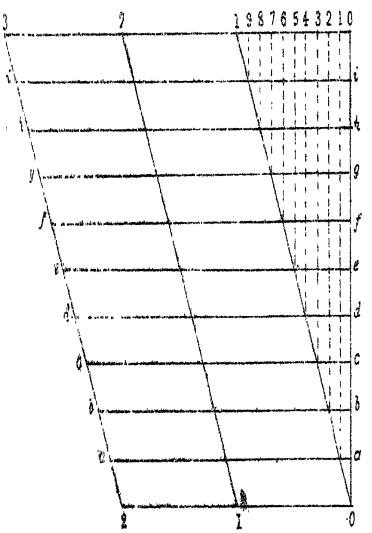


Fig. 6.

Fig. 7.
Area Comb

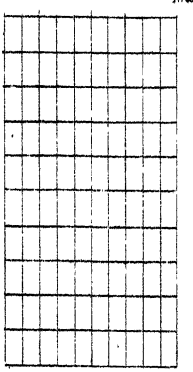


Fig. 8.

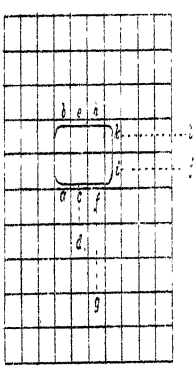


Fig. 8a.

Fig. 9.

Offset Scales

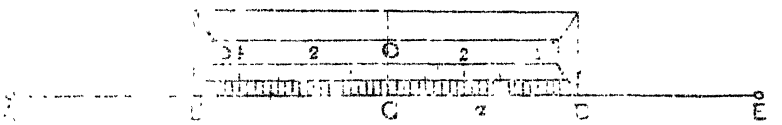


Fig. 10.

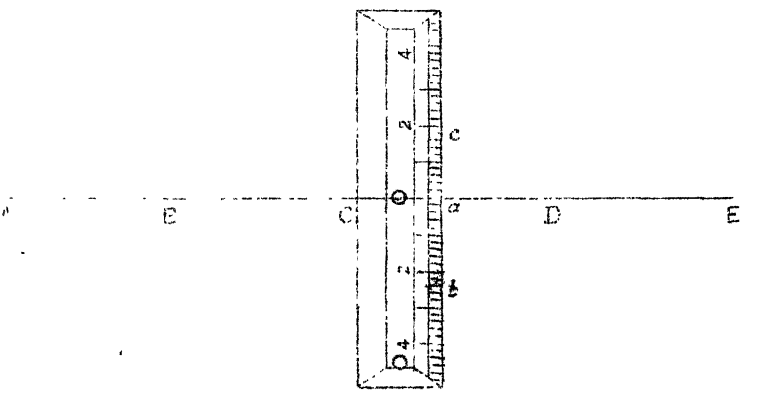


Fig. 13

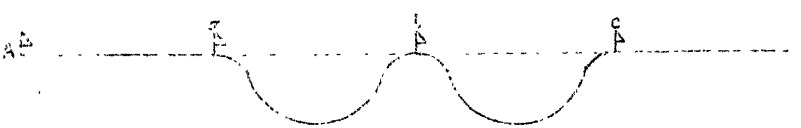


Fig. 14.

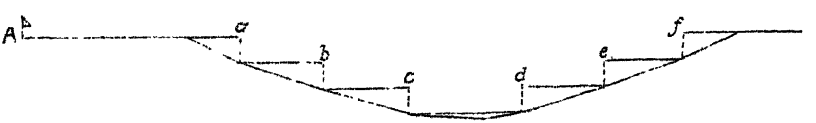


Fig. 11.

Magnetic Needle

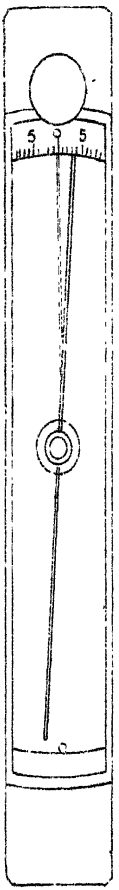


Fig. 12.

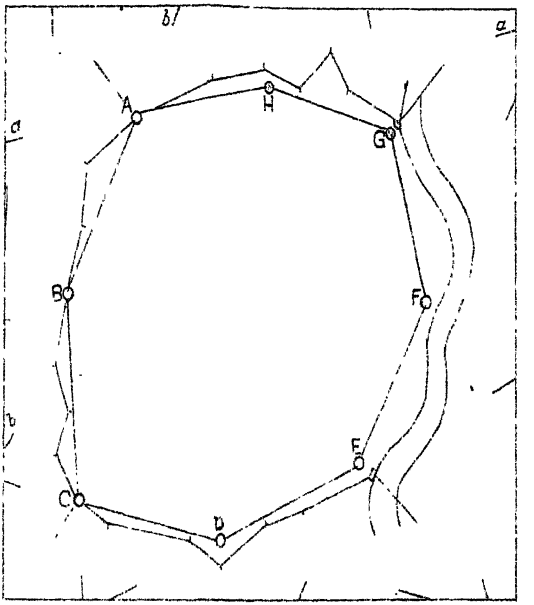
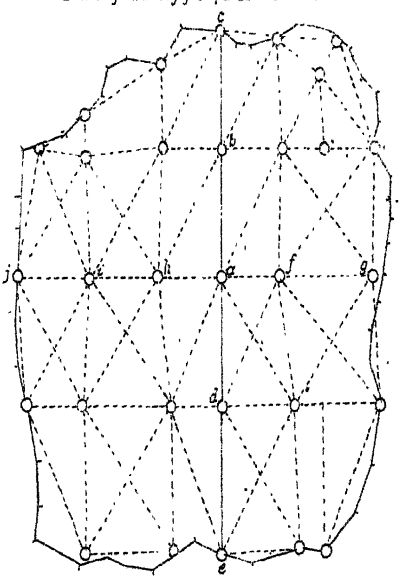


Fig. 15.

Plan of Survey from a central line



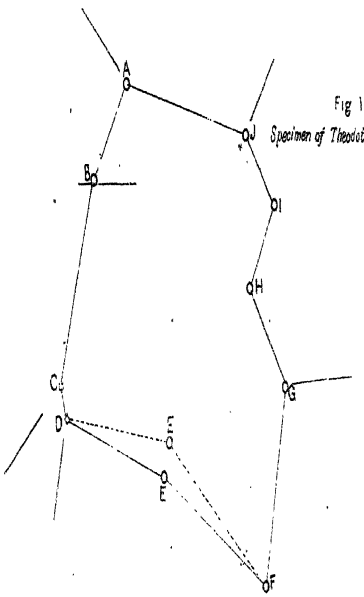


Fig 16.
Specimen of Theodolite Traverse Plot.

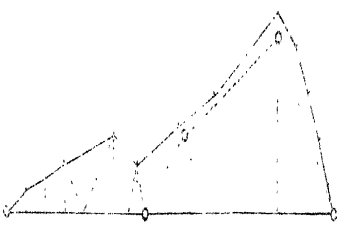


Fig 17.

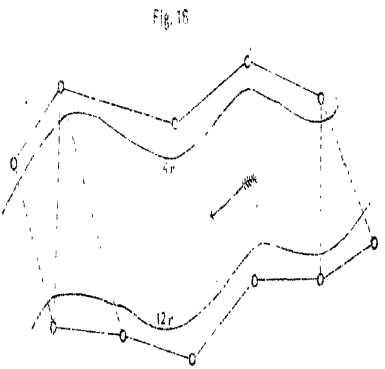


Fig 18.

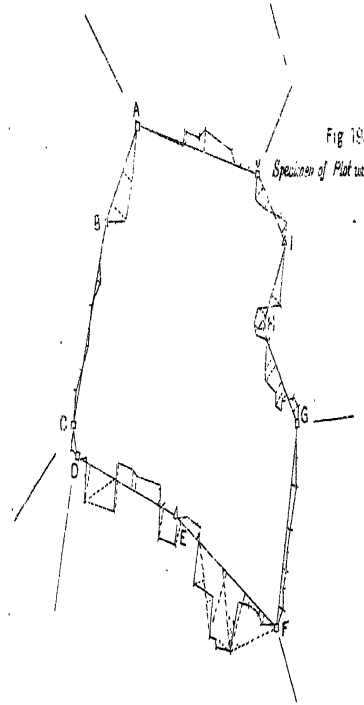


Fig 19.
Specimen of Plot with Boundary

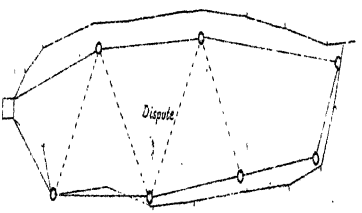


Fig. 20.

Fig. 21.

Specimen of Duplicate Plot or Khaka

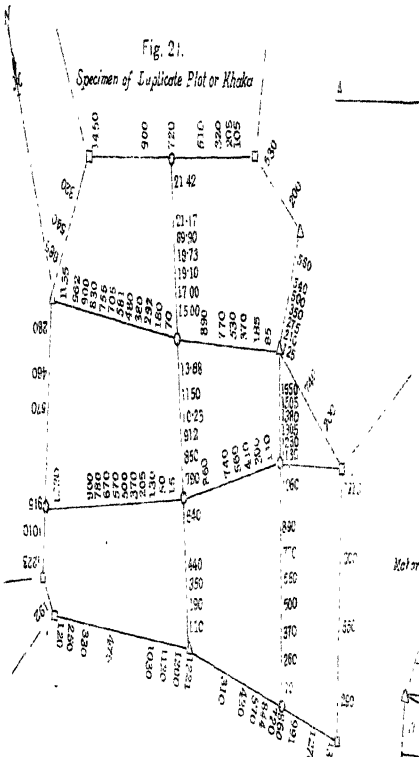


Fig. 22.

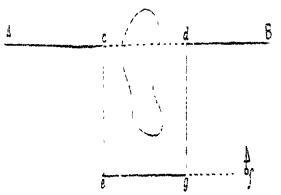


Fig. 23

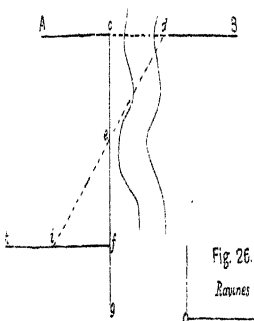


Fig. 24.

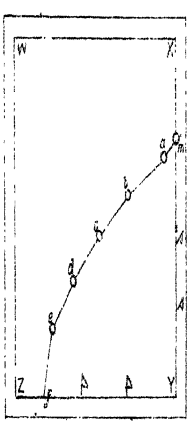
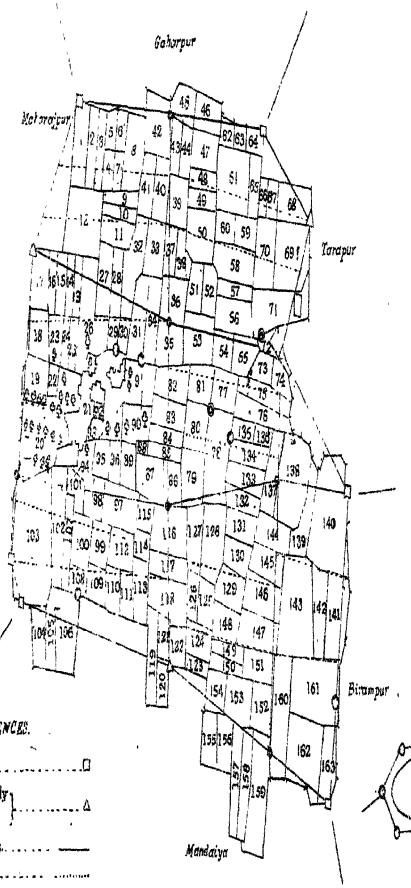


Fig. 25.

Specimen of completed Survey of a Village.



REFERENCES.

Injunction Platforms. . . . . □

Survey Stations permanently marked by stones. . . . . △

Quadrilaterals in firm lines. . . . . ——

Subsidiary in dotted lines . . . .

Fig. 26.

Ravines

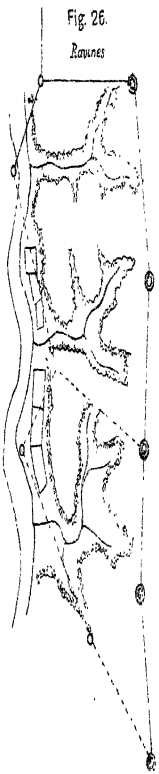


Fig. 27.